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Full Length Research

Effects of Vegetation Variables and Anthropogenic Activities on Threatened Bird Species in Fragmented Forest Patches of the Obudu Plateau, South Eastern Nigeria

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The present investigation was conducted in Obudu Plateau which is one of the most important single sites in Nigeria for the globally-threatened bird species: White-throated Mountain Babbler *Kupeornis gilberti*, Bannerman's Weaver *Ploceus bannermani* and Green-breasted Bush-shrike *Malaconotus gladiator* between 2014 and 2015. The result showed that vegetation height had a significant effect on the number of Bannerman's weaver and this increased with increase in forest productivity and anthropogenic activity while the number decrease with increase in forest compactness. Forest compactness had a significant effect on the number of White-throated mountain babblers and increased with increase in forest productivity but decreased with increase in anthropogenic activity and vegetation height. Vegetation variables are a reflection of the different land types on the Obudu plateau e.g. farming, felling of trees, grazing that reduces vegetation cover and complexity thus negatively affecting the threatened species. Alternatives should be provided to the communities to ease pressure on the forest as well as continued environmental education.

Key words: Birds, Fragmentation, Obudu, Threatened, Vegetation, Variables.

INTRODUCTION

Many of the world's forests are under threat. Despite all the national and international efforts, the annual loss of forest during the last decades amounted to approximately 15 million hectares worldwide (Food Agricultural Organization, FAO, 2001). Annual loss of forest area between 2000 and 2005 was 7.3 million hectares per year, an area about the size of Sierra Leon or Panama (FAO, 2005).

Tropical rainforests have received most of the attention concerning the destruction of habitat. From the approximately 16 million square kilometres of tropical rainforest habitat that originally existed

worldwide, less than 9 million square kilometres remain today (Primack, 2006). The current rate of deforestation is 160,000 Km^2 per year, which equates to a loss of approximately 1% of original forest habitat each year (Laurance, 1999).

Habitat fragmentation is recognised as a major threat to wildlife population worldwide (Rosenberg, et al., 1997; Harrison and Bruna, 1999). Habitat fragmentation and disturbance may have implications for biodiversity conservation and can affect a variety of population and community processes over a range of temporal and spatial scales (Saunders, et al., 1991; Debinski and Holt, 2000; Fahrig, 2003).

Tropical forests have often been regarded as ancient and changeless but it is now clear that they have been very dynamic over evolutionary and ecological times. The main effect of the Pleistocene glacial advances in tropical lowland forest was increased aridity, presumably resulting in contraction and fragmentation of most tropical forests into the most mesic parts of their current distribution, the now well known Pleistocene refugia. These repeated cycles of fragmentation into forest islands provided an ideal situation for allopatric differentiation in rainforest organisms and may have led to much speciation (Haffer, 1969).

While the Pleistocene fragmentation of tropical forests remains hotly debated, there is no doubt that an even more dramatic fragmentation of tropical forests is taking place today, this one induced by humans (Gentry, 1990). Tropical forests, originally covering 16% of the world's land area, are now reduced to 7% of the terrestrial surface (Mallingreau and Tucker, 1988), less than half their former extent, and the degradation rate is increasing. Between 1990-1995, 3.70 million of natural forest was loss in tropical Africa (FAO, 2005). In regions like Madagascar, coastal Ecaudor, and coastal Brazil, the tropical forests have been reduced to less than 10% of their former extent (Mallingreau and Tucker, 1988).

The Obudu Plateau is the most important single site in Nigeria for globally threatened bird species. It holds one endangered (White-throated Mountain Babbler *Kupeornis gilberti*) and two vulnerable (Green-breasted Bush-shrike *Malaconotus gladiator* and Bannerman's Weaver *Ploceus bannermani*) species. 'Endangered' applies to taxa in danger of extinction and whose survival is unlikely if the causal factors continue operating; 'Vulnerable' applies to taxa believed likely to move to the endangered category in the future if the causal factors continue operating (Collar and Stuart, 1985).

The Obudu Plateau is the westernmost extension of the Cameroon mountain forest, which is an Endemic Bird Area (EBA) (Ezealor, 2002). The distribution and population sizes of the three globally threatened species (White-throated Mountain Babbler *Kupeornis gilberti*, Bannerman's Weaver *Ploceus bannermani*, and Green-breasted Bush-shrike *Malaconotus gladiator*) on the Obudu Plateau, as well as the effects of forest land use types and fragmentation on them are presently unknown.

The physical structure of vegetation is considered an important habitat component for birds both directly, through the provision of food and indirectly in providing potential cues about the onset of conditions suitable for successful breeding (Wiens and Rotenberry, 1981).

Good vegetation can provide good protection from predators and a high diversity of insects at different stages of their life cycles, which means, a continuous supply of food for insectivorous birds. Trees in habitats also flower at different times of the year and this means fruiting trees are always available for frugivorous birds like African Green Pigeon (*Treron calvus*), Green Turaco (*Tauraco persa*) and African Grey Hornbill (*Tockus nasutus*). Flowering trees also ensure nectar diet for nectarivores such Scarlet Chested Sunbird (*Chalcomitra senegalensis*) (Woinarski et al., 1988). Seasonal fluctuation in the flowering and fruiting of plant species is also known to influence the distribution and abundance of many bird species, especially the highly mobile nectarivous species (Woinarski, et al., 1988). Hence, we conducted the research on Effects of Vegetation Variables and Anthropogenic Activities on Threatened Bird species in Fragmented Forest Patches of the Obudu Plateau, South Eastern Nigeria.

MATERIALS AND METHODS

Study Area

The present research was conducted in the Obudu Plateau (between 6°22′N 9°23′E and 6°30′N 9°15′E) which is a small Afro-montane area in Cross River State, south-eastern Nigeria, close to the border with Cameroon. The general elevation is about 1500 m, with a few summits rising to almost 2000 m. Most of the area, though originally forested, is now grassland, with forest confined to steep-sided valleys and scarps

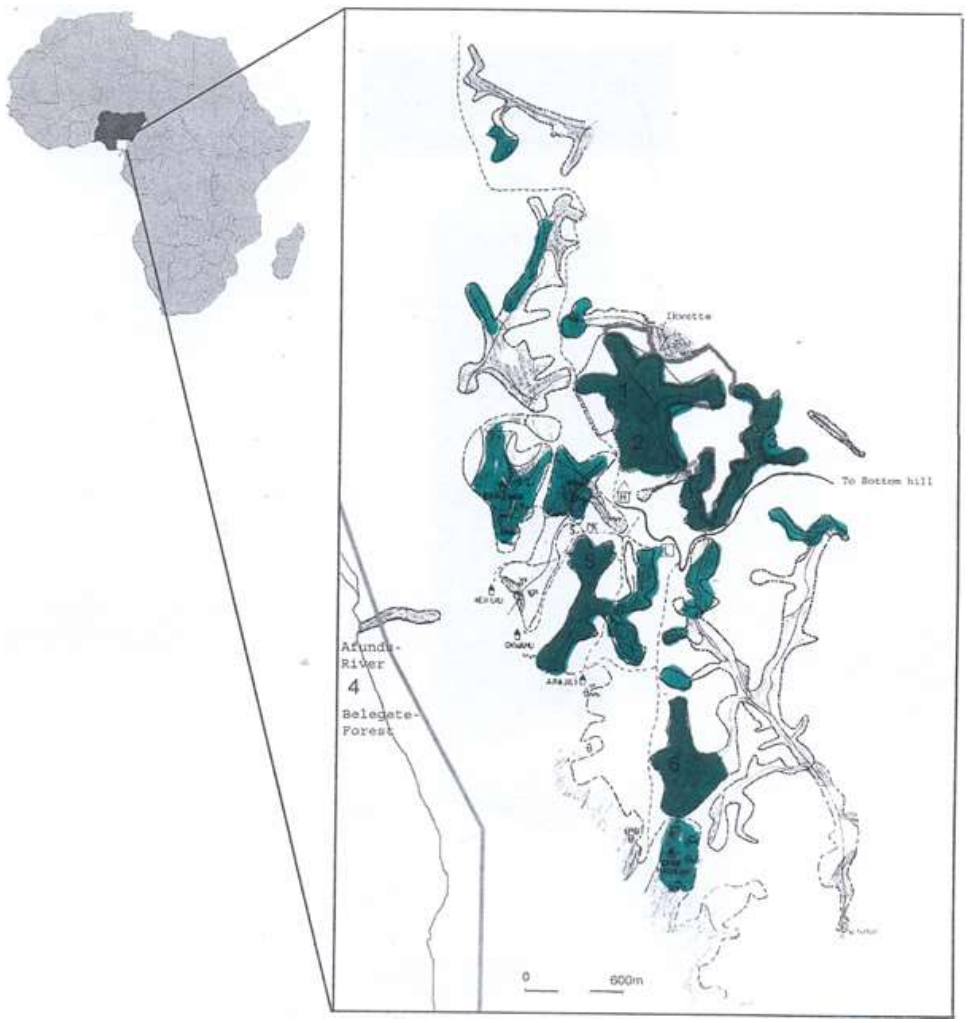

Figure 1. Study Site Showing Surveyed Forest Patches in Green (Remodelled after Rodenkirchen, 2002).

(Hall, 1981). Mean annual precipitation is high, at least 4,280 mm, falling mainly in a nine-month rainy season (March to November) and temperatures are comparatively low, with monthly means of 14-16 °C (daily minima) and 18-25 °C (daily maxima) (Hall, 1981). The whole area of the Obudu Plateau is 720 Km^2 but the forest within it covers a much smaller area (IUCN/UNEP, 1987; Figure 1).

Bird Survey

Point transects were used in this study because the terrain at Obudu Plateau is rugged with undulating hills and thick secondary growths that made access difficult otherwise Line transects could have been the best. All forest patches were traversed using the Garmin Global Positioning System (GPS MAP 60) tract log to generate waypoints and maps of all 31 forest patches. Each forest patch was named (coded), saved on the GPS and downloaded to the computer. Using the Map Source program points were laid out systematically to cover the forest interior, forest edge and surrounding grasslands (Figure 2). Points were laid at least 100m apart (Bibby et al., 2001). Points were downloaded to the GPS so that they could be identified in the field during survey. These were the points at which point counts were conducted.

Point Transects

Every morning (between 6.00am and 11.00am) of the

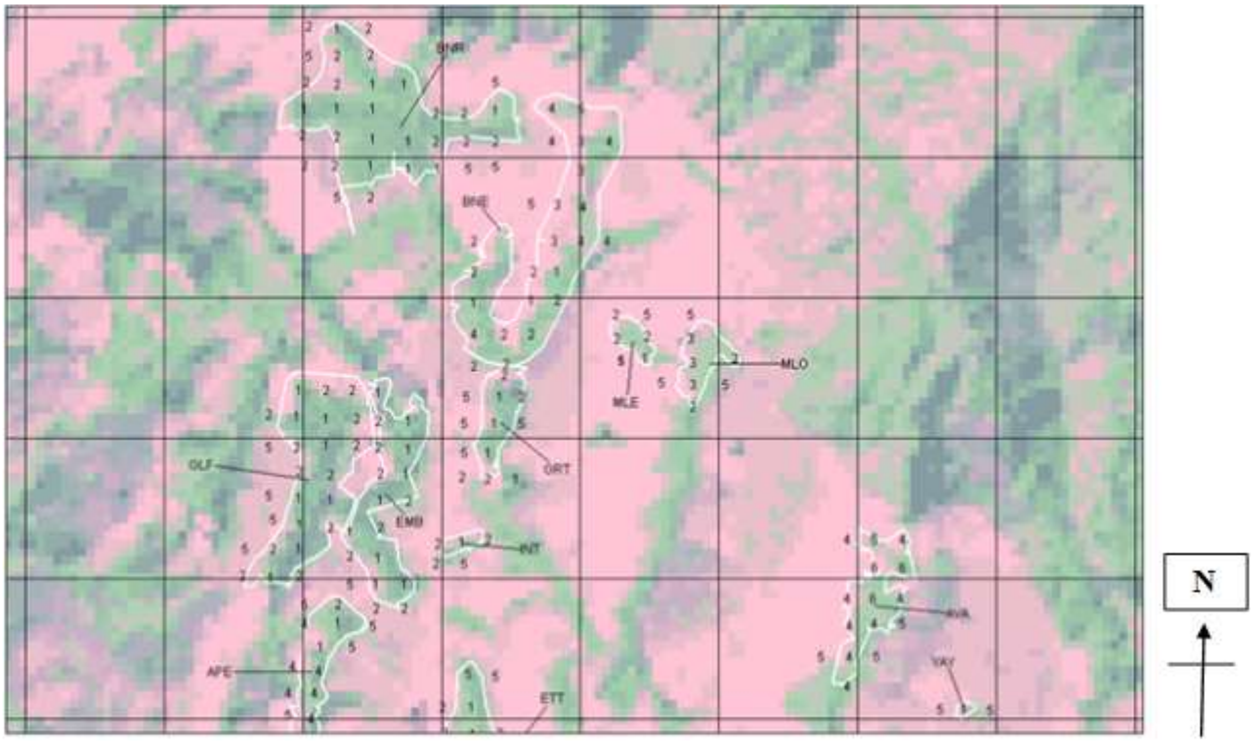

Figure 2. Points For Bird Counts Systematically Laid Out in Forest Patches.

survey, a map of the forest patch to be visited was used and the downloaded points on the GPS lead to each point. At each point, a 3-minute settling time was allowed before birds were recorded. All bird species and number of individuals heard or sighted were recorded and perpendicular distances to sighted bird species were noted using the Laser Range Finder (Bushnell YARD A GF PRO). The duration of recording was 4 minutes, alerted by an alarm clock (Bibby et al., 2001). Forest patches were visited three times each.

Bird species encountered in a forest patch that were distinct but not at a point were noted for each forest patch.

Measurement of Vegetation and Anthropogenic activities

At each point within a radius of 25m in all the forest patches surveyed, 4-four quadrats were made and in each the following measurements were made:
Number of trees, Number of trees with Diameter Breast Height <1cm, Number of trees with Diameter Breast Height 1-10cm, Number of trees with Diameter Breast Height >10cm, Percentage ground cover (to the nearest 5%) estimated by eye, Percentage litter cover (to the nearest 5%) estimated by eye, Percentage visible sky- by viewing the sky through the canopy from the wrong side of the binoculars (Jones et al., 1996), Presence or absence of flowering trees, Presence or absence of fruiting trees, Number of stumps, Percentage of agricultural activities (estimated to the nearest 5%) by eye, Presence or absence of cow dung, Presence or absence of traps, Number of climbers on trees, Percentage of moss on trees (estimated to the nearest 5%) by eye, Number of dead wood, Shrub height measured by an improvised meter rule, Grass height measured by an improvised meter rule.

STATISTICAL ANALYSIS

All the vegetation variables were tested for normality using the One-Sample Kolmogorov-Smirnov test. The Spearman Rank Correlation analysis was used to check for intercorrelation between the independent variables. Because of the large number of independent (predictor) variables (18) and confounding effects of multi-co-linearity (Gerard,

Table 1. Principal Components (PC)Used as Independent Factors in the Analysis of Number of Threatened Birds. Variables Included in the Interpretation of Each Principal Component (i.e. Those with Loadings > 0.5 or < – 0.5) are Identified in Bold.

Vegetation variables	PC1 (Forest Compactness)	PC2 (Forest Productivity)	PC3 (Anthropogenic Activities)	PC4 (Vegetation Height)
Skycov_mean	**-0.925**	-0.212	-0.025	0.144
Moss_mean	**0.920**	0.145	-0.018	-0.137
Treeheightm_mean	**0.907**	0.088	0.031	-0.156
Litcov_mean	**0.892**	0.164	-0.003	-0.064
Trees_mean	**0.837**	0.158	0.095	-0.218
Climbers_mean	**0.784**	0.123	-0.028	-0.067
Finger_mean	**0.674**	0.351	-0.034	-0.060
Treesflowering_mean	-0.028	**0.825**	0.030	-0.131
Ring_mean	0.443	**0.641**	0.085	0.070
Treesfruiting_mean	0.401	**0.551**	-0.062	0.030
Stumps_mean	-0.036	0.197	**0.836**	-0.059
Agriculture_mean	-0.176	-0.084	**0.820**	-0.139
No.deadwood_mean	0.351	0.011	**0.594**	0.006
Shrubheight_mean	-0.155	0.020	-0.017	**0.844**
Grassheight_mean	-0.242	-0.039	-0.156	**0.752**
@2hand_first	0.354	0.471	0.279	0.107
Cowdung_mean	-0.415	-0.111	-0.186	0.099

KMO = 0.89; Bartlett's sphericity test *df* = 136, $\chi 2$ = 3737.07, *P* < 0.001.

2001), a principal component analyses were performed to reduce the independent factors into non-correlating components (Pearson, 1901; Jolliffe, 2002; Budaev, 2010). These non-correlating components were selected based on the rotation technique of Varimax with Kaiser Normalization (Jolliffe, 2002; Budaev 2010). Bartlett's sphericity test and the Kaiser-Meyer-Olkin (KMO) test were used to analyse sampling adequacy of the correlation matrix – use of the correlation matrix is appropriate if the hypothesis of all zero correlations is rejected (i.e. if the *P*-value of Bartlett's sphericity test is < 0.05) and when KMO > 0.6 (Budaev, 2010). Variables retained for the interpretation of each principal component are those whose loadings are > 0.5 or < – 0.5 (Budaev, 2010).

The vegetation variables retained for the interpretation of each principal component are those whose loadings were > 0.5 or < – 0.5 (Budaev, 2010) (Table 1). Four principal components (PC1 = Forest compactness; PC2 = Forest productivity; PC3 = Anthropogenic activities and PC4 = Vegetation height: Table 1) were eventually selected which accounted for 66.34 % of the variance in these eighteen variables. The Generalised Linear Model (GLM) was further used to check the effect of the selected principal components on the dependent variables (number of threatened birds). The stepwise backward elimination approach (in which the least significant variable was eliminated at a time) was used to arrive at best model accounting for most of the variation in the dependent variable based on the adjusted R-squared (R^2).

RESULTS

The best model explaining most of the variation in the number of Bannerman's Weaver and giving a significant effect is the principal component related to vegetation height (PC4), (GLM, $F_{1, 216}$=5.08, P=0.03). Number of Bannerman's Weaver increased with increase in PC4, PC3 and PC2 (Figures 2 to 5) while it decreased with an increase in PC1 (Figure 6). The

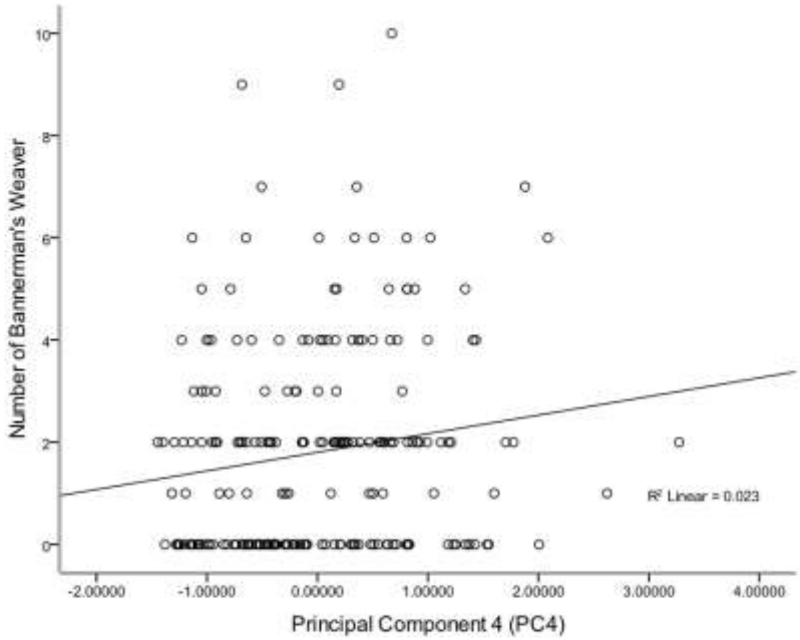

Figure 3. Relationship Between Number of Bannerman's Weaver and Vegetation Height (PC4).

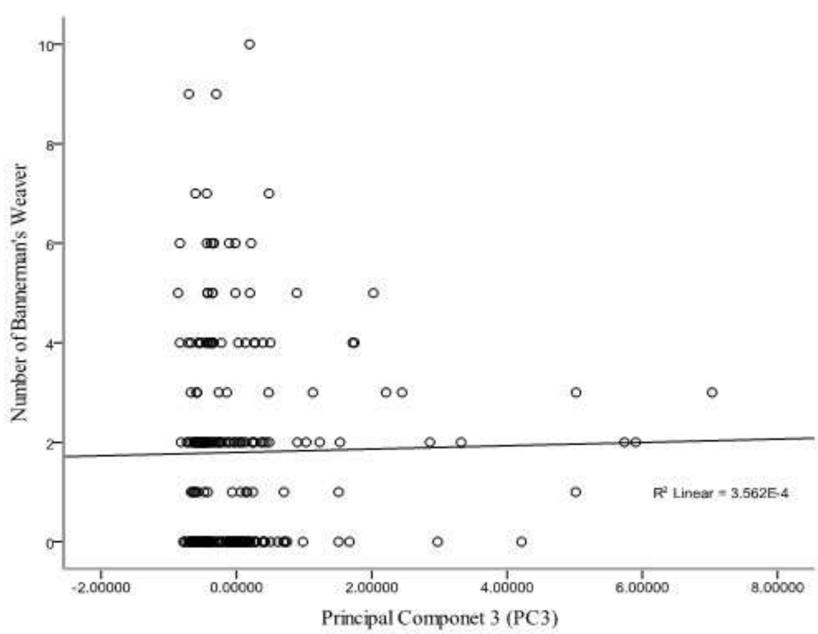

Figure 4. Relationship Between Number of Bannerman's Weaver Anthropogenic Activities (PC3).

best model explaining most of the variation in the number of White-throated Mountain Babblers and giving a significant effect is the principal component related to Forest Compactness (PC1), (GLM, $F_{1,}$

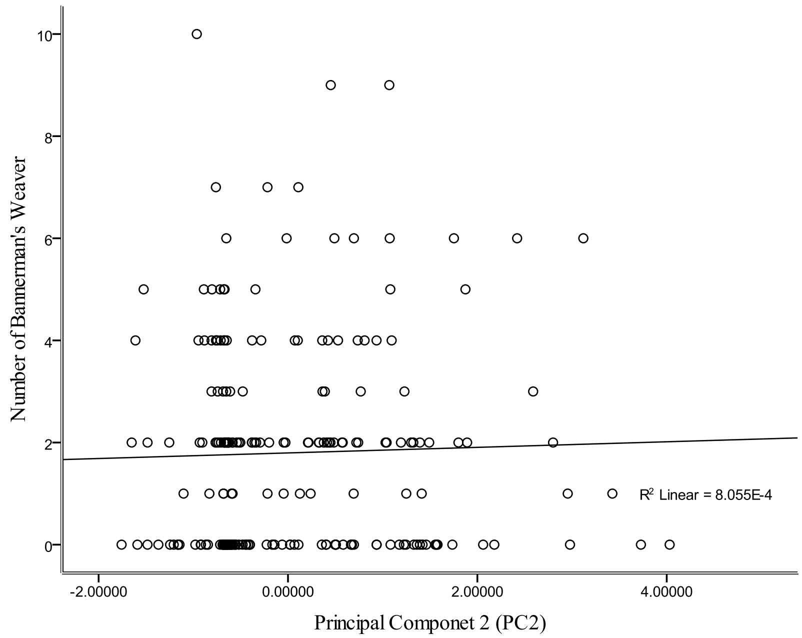

Figure 5. Relationship Between Number of Bannerman's Weaver and Forest Productivity (PC2).

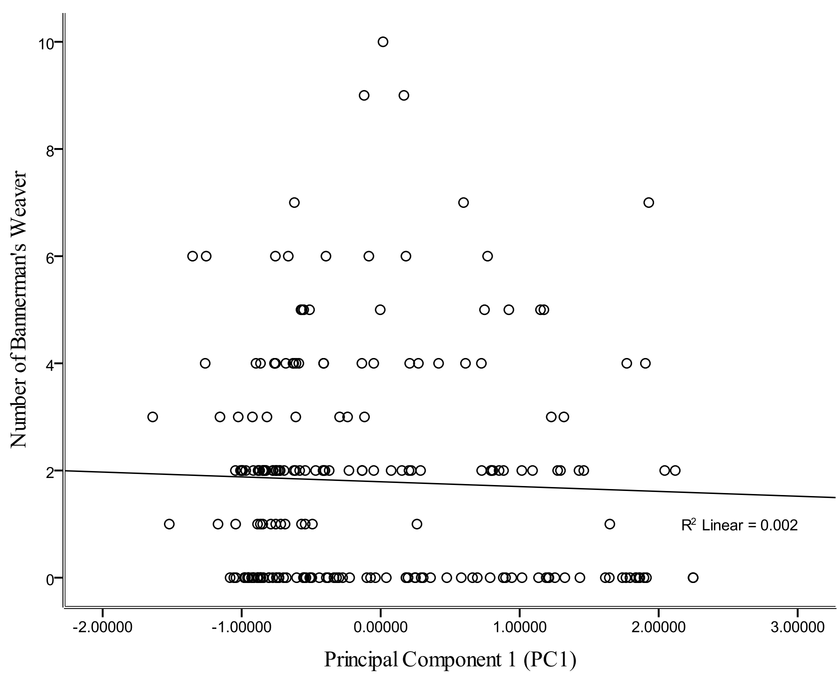

Figure 6. Relationship Between Number of Bannerman's Weaver and Forest Compactment (PC1).

$_{121}$=5.08, P<0.001). Number of White-throated Mountain Babblers increased with increase in PC1and PC2 (Figures 7, 8) and decreased with an increase in PC3 and PC4 (Figures 9 and 10).

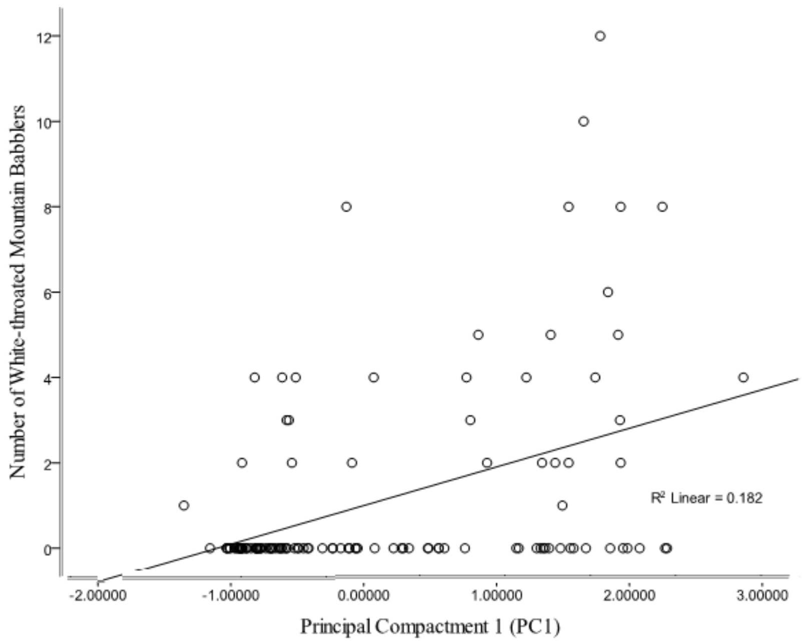

Figure 7. Relationship Between Number of White-throated Mountain Babblers and Forest Compactness (PC1).

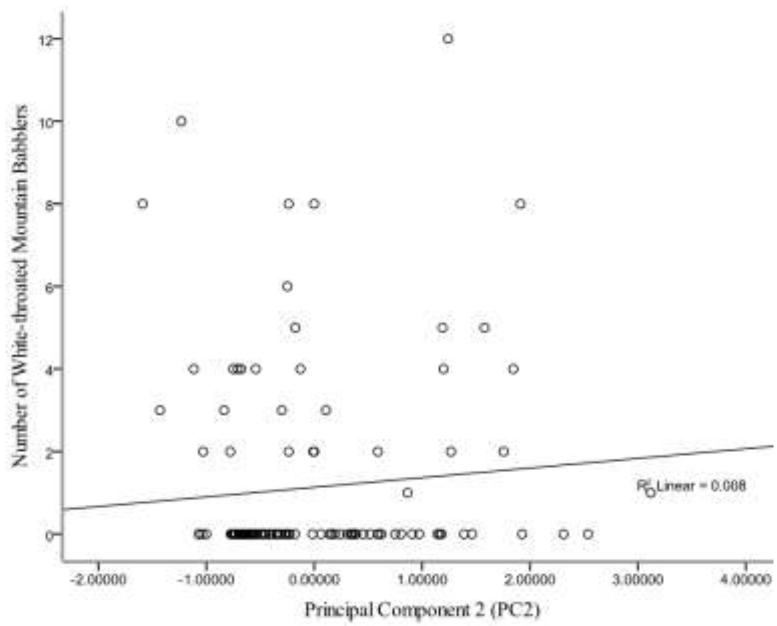

Figure 8. Relationship Between Number of White-throated Mountain Babblers and Forest Productivity (PC2).

DISCUSSION

Bannerman's Weaver

Vegetation height was the best model that described the effect of vegetation variables on the number of Bannerman's Weaver. These is expected because the species is an edge species (Collar and Stuart, 1985) and at the edge of forests are found the grasses, shrubs which were the vegetation variables

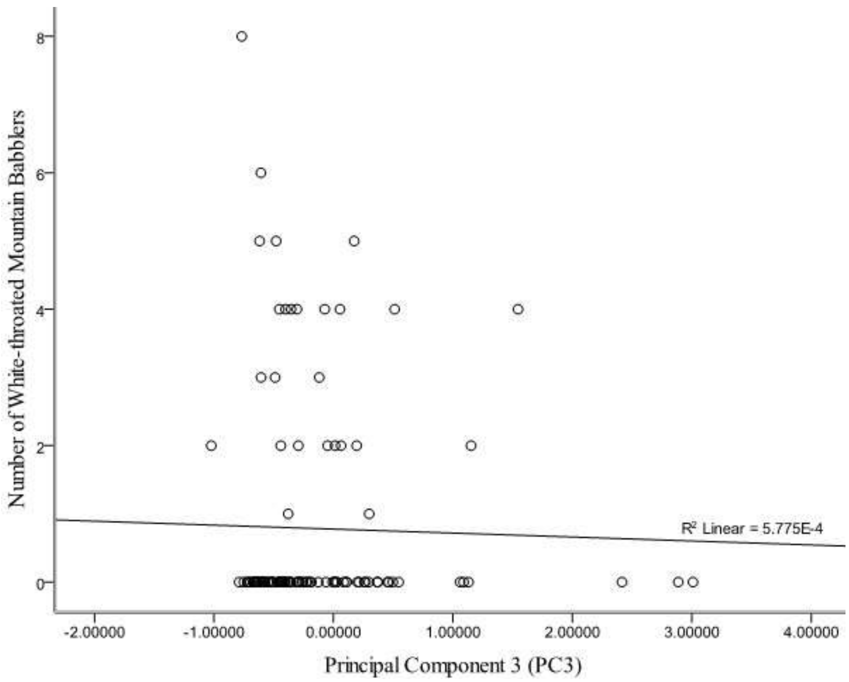

Figure 9. Relationship Between Number of White-throated Mountain Babblers and Anthropogenic Activities (PC3).

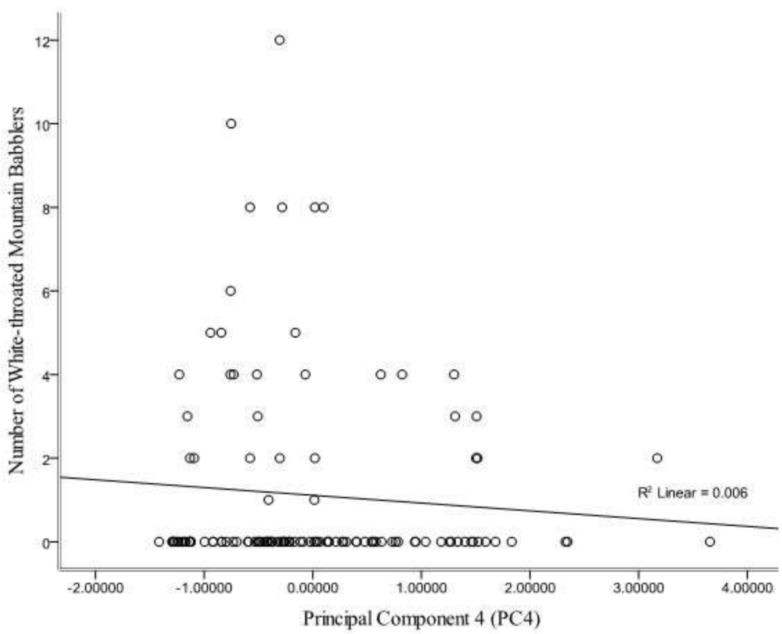

Figure 10. Relationship Between Number of White-throated Mountain Babblers and Vegetation Height (PC4).

that made up the principal component vegetation height (Qiongyu et al., 2014). Numbers of Bannerman's Weavers were found to increase with principal components namely , forest productivity,

anthropogenic activities and vegetation height. Anthropogenic activities (measured by number of stumps, presence of agriculture and number of dead wood) clear forest patches and creates openings, gaps and edges that are favourable for the species thus the increase in numbers with increase in the activity. The vegetation height and forest productivity have to do with shrub and grass heights, trees fruiting and flowering which are found at this edges that increase the number of Bannerman's Weavers (Qiongyu et al., 2014). Numbers of Bannerman's Weavers were found to decrease with principal components 1(sky cover, percentage moss, tree height, Litter cover, number of trees and number of climbers). This is probably because principal component 1 had sky cover, moss mean, tree height, litter cover, presence of climbers as vegetation variables which describe forest interior and the species are edge species (Stattesfield et al., 1998).

White-throated Mountain Babbler

Forest compactness was the best model that described the effect of vegetation variables on the number of White-throated Mountain Babblers. This is expected because the species is usually found in the canopy of primary forest, although it is occasionally seen in mature secondary growths (Serle, 1954 as cited by Collar and Stuart, 1985). The species is mainly insectivorous and the birds search for food in moss, epiphytes and crevices in bark (Serle, 1954; Dyer, 1983 pers. Comm. and Gartshore, 1983 pers. Comm. All cited by Collar and Stuart, 1985) and forest compactness had vegetation variables sky cover, tree height, presence of moss, litter cover and climbers.

Numbers of White-throated Mountain Babblers were found to increase with principal components 1 and 2 (sky cover, percentage moss, tree height, Litter cover, number of trees and number of climbers, number of trees flowering and number of trees fruiting). This is because these components show the compactness and productivity of the forest on which the Babblers depend (Serle, 1954 as cited by Collar and Stuart, 1985). On the other hand, numbers of White-throated Mountain Babblers were found to decrease with principal components 3 and 4 (Number of stumps, percentage agriculture, number of dead woods, shrub height and grass height).

Anthropogenic activity destroys the forest compactness, canopies and moss plants that the Babblers depend on and thus the decrease in number. Vegetation height also does not depict the type of habitat structure preferred by the Babblers because their habitat is tropical moist montane forest (Dami et al., 2014).

CONCLUSION

Finally it is concluded that forest compactness was described the best vegetation variables associated with White-throated Mountain Babblers and their numbers increase with an increase in forest compactness and forest productivity and decrease with anthropogenic activities and vegetation height while vegetation height best describes the vegetation variable associated with Bannerman's Weaver and their numbers increase with an increase in vegetation height, anthropogenic activities and forest productivity and decrease with forest compactness.

RECOMMENDATIONS

1. Trees native to the Obudu Plateau should be planted and maintained on the Ranch to serve as connections or corridors. The work of Cross River Forestry Commission should be maintained and properly supervised.
2. Forest blocks should be planted with exotic and native trees that will be used by the community for their timber and firewood. This is to reduce the pressure on the forest patches.
3. Fuel-efficient stoves should be introduced to reduce firewood consumption by the local people, which will in turn result in a reduction in forest destruction through firewood gathering.
4. Alternative sources of livelihood such as small businesses should be introduced to empower the people economically.
5. Continued environmental education especially in schools (primary and secondary) on the importance of the conservation of these threatened bird species and other natural resources should be emphasized.
6. Cattle graziers should be made to construct fences around their Rangelands (by legislation) so that the cattle do not enter into the unprotected forest patches and degrade them.

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